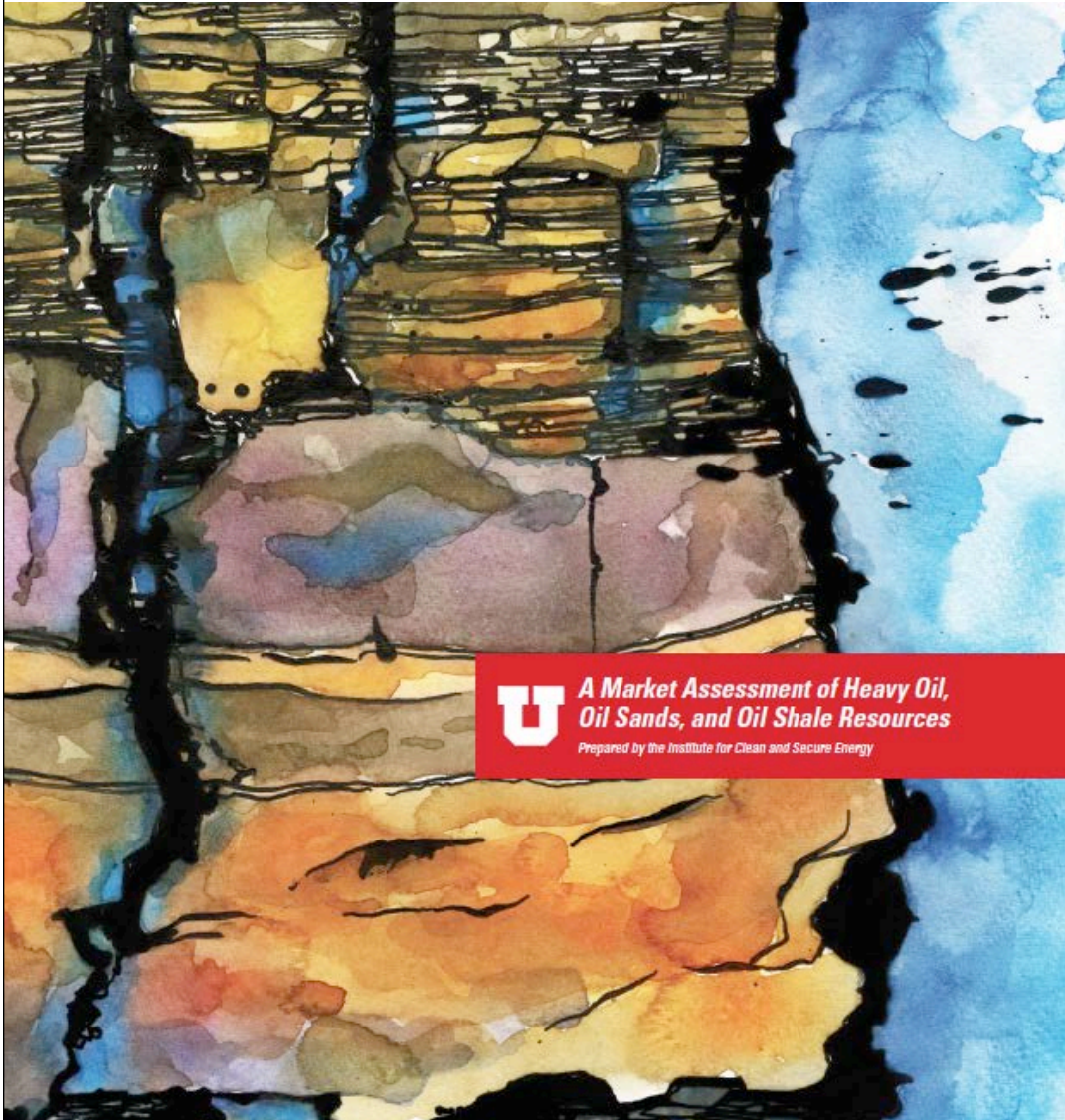


Multidisciplinary Oil Sands Research at The University of Utah

**College of Engineering, College of Law/Stegner
Center, College of Science, Utah Bureau of
Economic & Business Research**

**THE INSTITUTE FOR CLEAN AND SECURE ENERGY
AT THE UNIVERSITY OF UTAH**

An Example - Market Assessment of Unconventional Fuel Resources in Utah



**A Market Assessment of Heavy Oil,
Oil Sands, and Oil Shale Resources**

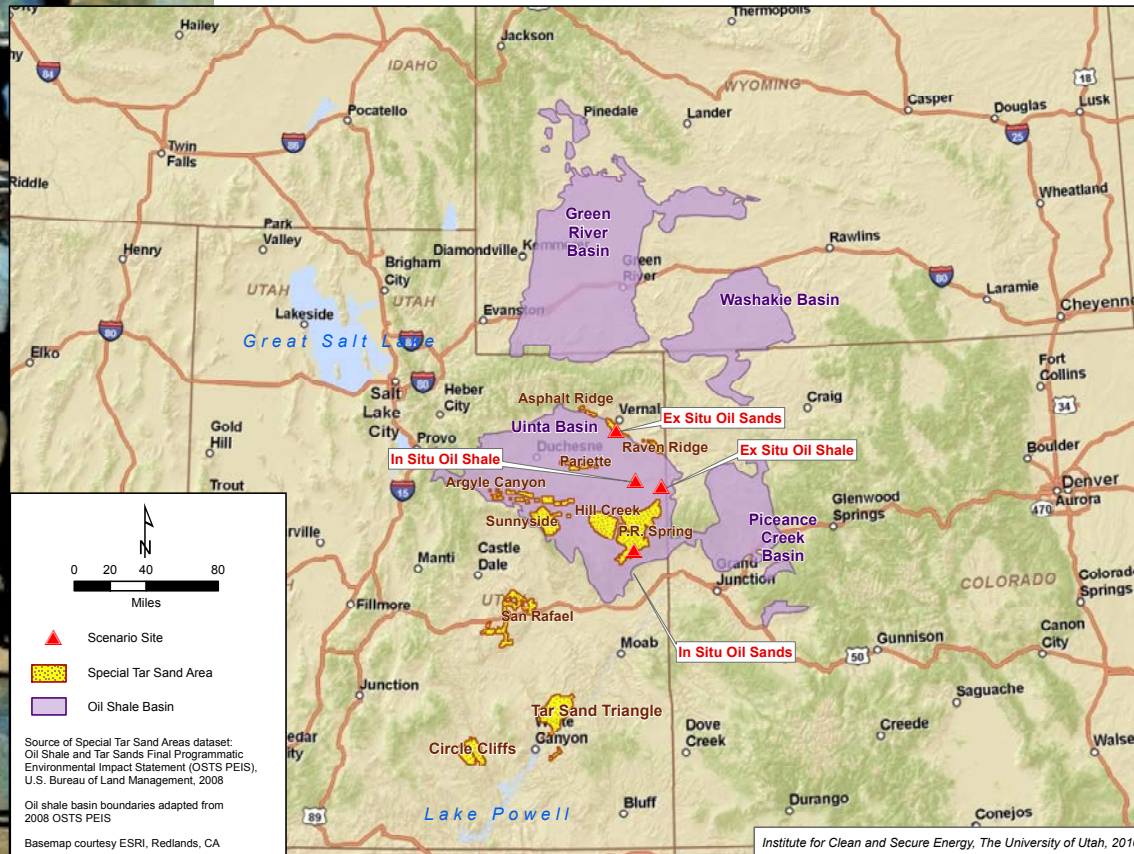
Prepared by the Institute for Clean and Secure Energy

- No commercial scale production of U.S. oil sands. What are development hurdles that exist (policy, environmental, technological, financial)?
- Market Assessment is the result. It covers:
 - ➔ Fiscal systems for securing a fair return: (1) determination of value of unconventional oil resource, & (2) policy instruments available for realizing that value. Alberta royalty regime as an example of a public policy tool.
 - ➔ Diverse public costs (externalities) associated with unconventional fuel development; public perception of cost can impact feasibility of development as much or more than actual cost and may not correlate to measurable scope of that cost.
 - ➔ Arguments in favor of development: (1) “Energy security” resulting from increased domestic production; (2) Unconventional fuel development will benefit U.S. in terms of job opportunities
 - ➔ Water uses & availability, land use impacts, air quality, carbon management
 - ➔ Four development scenarios



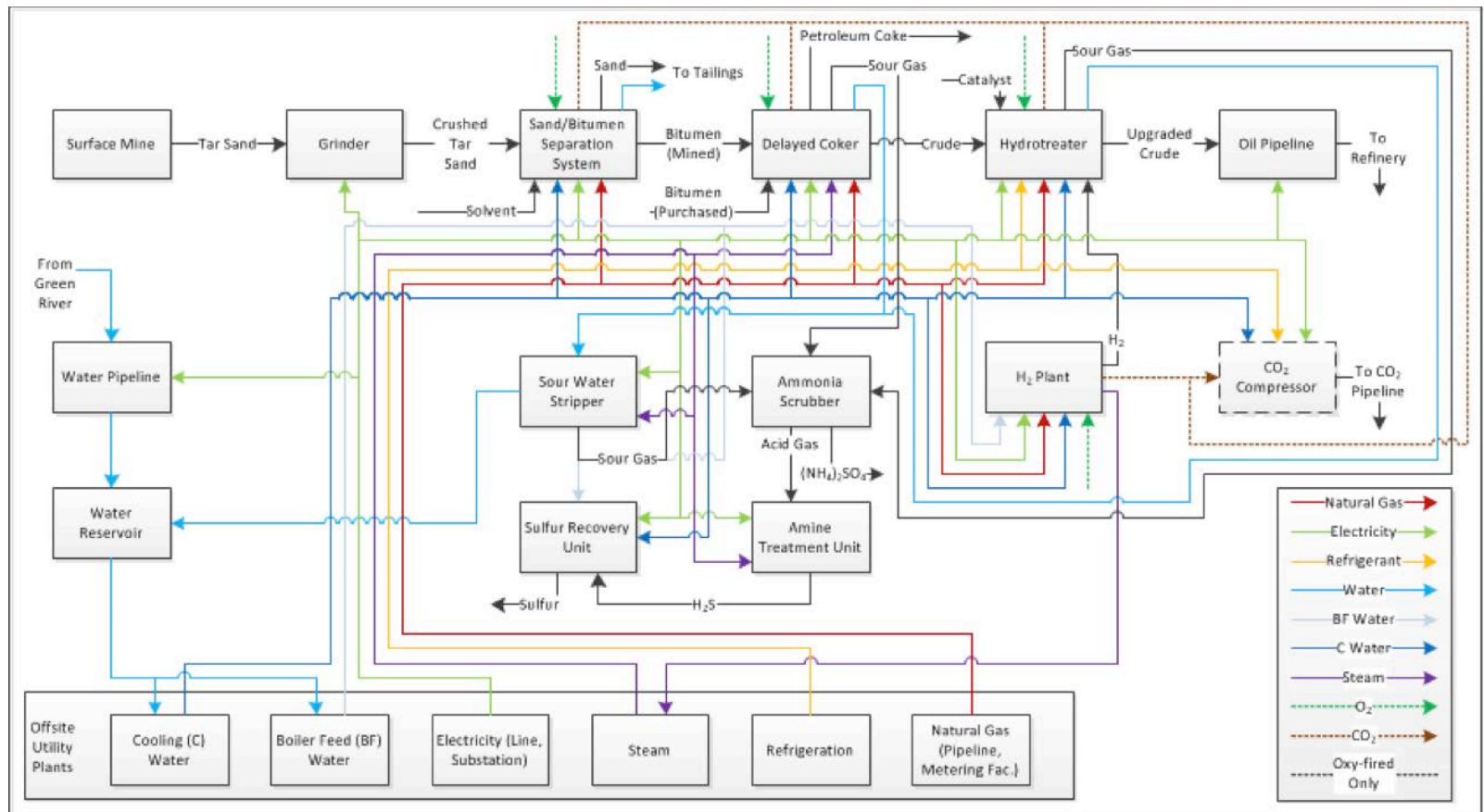
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Scope of Assessment Scenarios



- Report on profitability of 4 potential development projects: 50,000 BPD for oil shale; 10,000 BPD for oil sands; WTI-equivalent product; air- & oxy-fired; 4 years to design/build, 2 years ramp up to full production, 18 years of full production
 - ➔ Ex situ extraction (underground mining, surface retort) of oil shale
 - ➔ In situ extraction (conduction heating) of oil shale
 - ➔ Ex situ extraction (surface mining, surface processing) of oil sands
 - ➔ In situ extraction (SAGD) of oil sands
- Estimating costs for extracting, upgrading, and transporting these resources to market (refinery)
 - ➔ Applying same costing methodology to all scenarios
 - ➔ Itemizing all costs for each process
 - ➔ Investigating uncertainty associated with inputs & assumptions for each scenario & reporting impact on economic viability

Ex Situ Oil Sands Production Process Overview



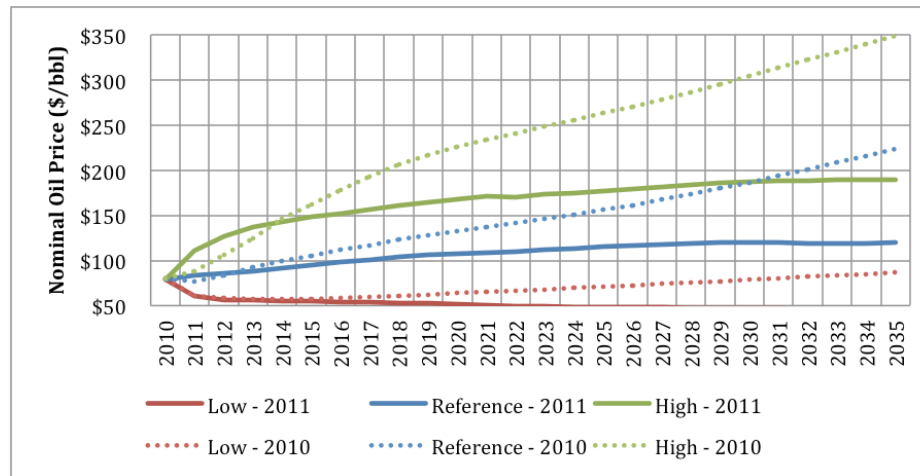
- Assume that mine on Asphalt Ridge can produce enough material to support 10,000 BPD operation. Mine is 7.4 km long, 300 m wide, oil sands layer is 18.3 m thick at a down dip angle of 12°. Mine to stripping ratio of 4:1. Bitumen content of sands is 10 wt%.

Water Requirements

Category	Item	Water (bbl / bbl of oil)		Water (acre-ft/yr)	
		Air-Fired	Oxy-Fired	Air-Fired	Oxy-Fired
Neutral	Cooling Water				
	Hydrotreater	0.12	0.12	54.70	54.70
	H2 Plant	1.07	1.07	502.16	502.16
	Extraction	0.21	0.21	-	8,856.38
	Delayed Coker	0.02	0.02	32.54	32.54
	CO2 Compressor	-	18.82	-	8,856.38
	Sulfur Recovery Unit	0.07	0.07	32.54	32.54
	Boiler Feed Water				
	Sulfur Recovery Unit	0.01	0.01	4.88	4.88
	Subtotal	1.50	20.32	626.81	18,339.58
Consumed	H2 Plant	0.38	0.38	178.65	178.65
	Tailings/Sand	1.04	1.04	487.45	487.45
	Subtotal	1.42	1.42	666.10	666.10
Generated	CO2 Compressor	-	0.54	-	254.32
	Subtotal	-	0.54	-	254.32
Recycled	Recycle losses	0.06	0.62	26.48	292.17
	Subtotal (Neutral - Losses)	1.44	19.70	600.33	18,047.41
Water In		1.47	1.50	692.58	703.95

- Each part of oil sands production process generates water, consumes water, or is water neutral.
- Water losses include evaporation in cooling towers, moisture in sand tailings, consumption for H₂ production.
- Volume of water required for one-time filling of tanks for startup not included

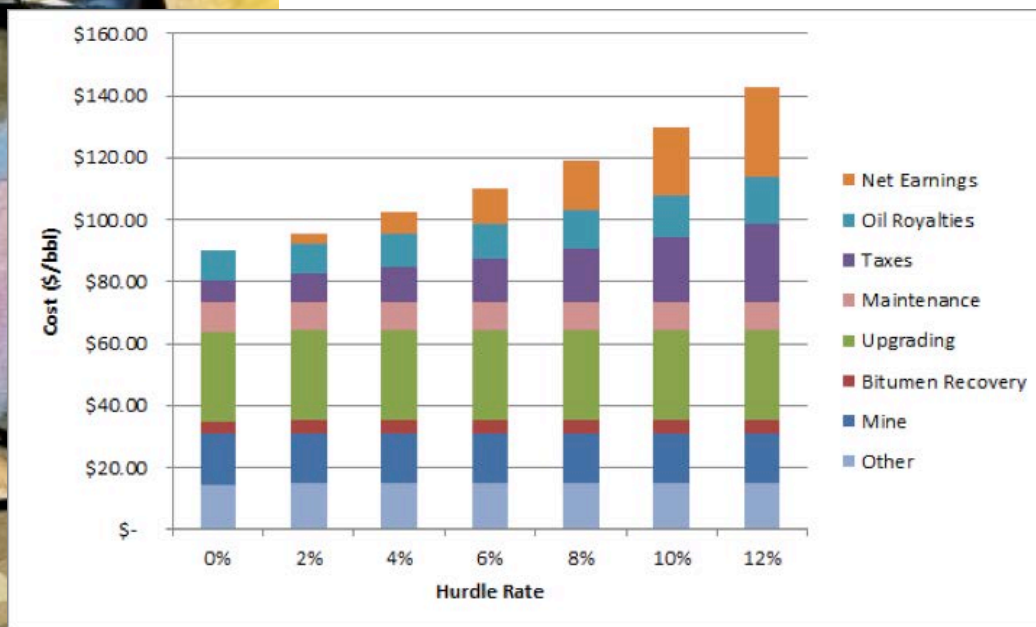
Measures of Profitability



- Discounted cash flow analysis (function of discount factor & annual cash flow)
 - ➔ $NPV = \sum_{k=1}^n f_n CF_n$ where $f_n = \frac{1}{(1+r_d)^n}$
- Supply Price Method
 - ➔ Minimum constant dollar price per barrel of oil to ensure a profitable project; real fixed price that results in $NPV = 0$
 - ➔ Includes all usual costs (capital expenditures, operating costs, royalties, taxes, etc.) plus a necessarily & sufficiently attractive return on investment (normal profit or hurdle rate)
- Net Present Value Method
 - ➔ Specify an oil price forecast & hurdle rate, calculate NPV
 - ➔ Negative NPV = operation not profitable
 - ➔ Positive NPV = profitable operation.

Profitability Analysis

Supply Price Method



NPV Method

Hurdle Rate	EIA Price Forecast		
	Low	Reference	High
0.0%	\$ (1.75)	\$ 1.09	\$ 3.33
2.0%	\$ (1.47)	\$.67	\$ 2.36
4.0%	\$ (1.27)	\$.37	\$ 1.67
6.0%	\$ (1.13)	\$.15	\$ 1.17
7.9%	\$ (1.02)	\$ -	\$.82
8.0%	\$ (1.02)	\$ (.01)	\$.80
10.0%	\$ (.93)	\$ (.12)	\$.53
12.0%	\$ (.87)	\$ (.21)	\$.32
16.9%	\$ (.76)	\$ (.34)	\$ -